Iodine excretion in school children in Copenhagen

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ABSTRACT

INTRODUCTION: Studies of dietary habits show a high iodine intake in children in Denmark. Iodine excretion in children has not previously been assessed. Iodine excretion in adults is below the recommended threshold, and it is therefore being discussed to increase the fortification level. The main objective of this study was to assess iodine excretion in children living in Copenhagen to establish whether a moderate increase in iodine fortification would lead to excess iodine intake in this group.

METHODS: Children in first and fifth grade were recruited through schools in Copenhagen. In total, 244 children delivered a urine sample. Urine samples were analysed for iodine and creatinine, and the results were expressed as urinary iodine concentration (UIC) and as estimated 24-h iodine excretion. Iodine excretion in children was also compared with that of adults living in the same area, investigated in a prior study.

RESULTS: The median UIC was within the recommended level; 145 (range: 116-201) µg/l for boys and 128 (range: 87-184) µg/l for girls, and was lower in fifth grade students than in first grade students. Estimated 24-h iodine excretion was higher in boys than in girls, but did not differ according to grade. The UIC was higher in children than in adults from the same area.

CONCLUSIONS: The iodine excretion among schoolchildren in Copenhagen, an area with a relatively high iodine content in tap water, was within the recommended range as assessed by the UIC. An increased iodine fortification will not have negative consequences for this group.

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TRIAL REGISTRATION: not relevant.

Iodine is a key element in the synthesis of thyroid hormones. Urinary iodine excretion is a marker of recent dietary iodine intake and is used to monitor iodine status in a population [1]. Iodine excretion in Danish adults has been assessed in the DanThyr cross-sectional and follow-up studies [2, 3]. The last of these studies, carried out in 2008-2010, showed a small decrease in iodine excretion and a median urinary iodine concentration (b) just below the recommended 100 µg/l [2]. It is therefore being contemplated if the mandatory iodine fortification of salt and bread should be increased to achieve an optimal iodine status in the Danish population.

Data on iodine excretion in children in Denmark are lacking. The only data are from a recent study where iodine excretion was assessed in 51 children as part of an investigation of iodine status in pregnant women and their families in Aalborg [4]. The urinary iodine concentration (UIC) was 125 µg/l in these children. This was higher than the iodine excretion in their parents [4], and also higher than the excretion measured in adults in Aalborg [3].

When expressed as estimated 24-h iodine excretion (using creatinine excretion to correct for hydration), the median was 63 µg/day [4]. This value can be compared with the recommended intake, which is 120 µg/day for children aged 6-9 years [5]. Thus, according to this study, the UIC in children was within the optimal range [1], but the estimated 24-h iodine excretion showed a low iodine intake.

Iodine intake has been estimated in both adults and children in the Danish National Survey of Dietary Habits and Physical Activity in 2011-2013 [6]. In this study, a high iodine intake was found in Danish children and adults; 222 µg/day in 4-9-year-old children (n = 421) and 247 µg/day in adults (n = 3,016). This intake does not include a possible intake from dietary supplements. There are some uncertainties in the calculation of iodine intake as the calculations depend on the iodine content of food given in the food database and the recording of food intake. However, the estimated high iodine intake gives cause for concern when discussing an increase of the iodine fortification level in Denmark. The iodine content in tap water differs geographically within Denmark. Aalborg has a relatively low iodine content in tap water, whereas Copenhagen has a relatively high iodine content in drinking water [7]. There-fore, the main objective of this study was to assess iodine excretion in schoolchildren living in Copenhagen to establish whether a moderate increase in iodine fortification would lead to excess iodine intake in this group. An additional objective was to compare the iodine excretion in schoolchildren with the iodine excretion in adults from the same geographical area.

METHODS

A one-stage cluster sampling method was used. All schools in the school districts of Bispebjerg, Nørrebro, Østerbro and Brønshøj were invited to participate. These areas were selected to cover the same areas as previous studies in adults (the DanThyr Study) [3]. The sampling was done from March to May 2015.

In total, 23 schools were contacted and eight agreed to participate. When the school agreed, invitation letters were delivered to all students in first and fifth grade. The letters included a short invitation letter, an information sheet about the study, a short questionnaire, an informed consent form for the parents to sign and a stamped envelope. In total, 1,030 students were invited and we received 276 signed informed consents. Of these, 11 students were sick when we visited the school or did not give a urine sample for other reasons: 21 of the signed informed consents arrived after we visited the school, leaving 244 children (23.7%) who delivered a urine sample. The participation rate was 22.4% among students in first grade and 26.8% among students in fifth grade.

The study was approved by the local ethics committee (record no.: N-19960208mch).

Questionnaire

A short questionnaire with questions regarding the child's gender, age, school, ethnicity, use of medication and use of dietary supplements with iodine and the dose of these supplements was filled in by the parents and returned together with the informed consent form.

Measurements

The height and weight of the children were measured at the school using the scale available at the school nurse room. These measures were done with light clothes and without shoes. Most of the children collected a spot urine sample at a specific toilet at the school between 8 am and 4 pm. A minority of the children collected the urine sample at home and brought it to the school the next day to be handed in to a project employee. The urine samples were frozen the same day as delivered and kept at –20 °C until the day of analysis.

Adult study

Iodine excretion data were collected in adults from the same areas in Copenhagen in 2008-2010. Results from this previous study have been described and published [3]. Some data are included in the present article to be able to compare iodine excretion in these adults with iodine excretion in the children. Data from a study of pregnant women in Copenhagen were also included to compare iodine excretion in children with iodine excretion in this group. Data collection and results are described in a separate article [8].

Analyses

Iodine in urine samples was measured by the cerium/arsenite method after alkaline ashing, as previously described [9]. The analytical sensitivity was 2 µg/l and the recovery was > 95%. When a urine sample was repeatedly measured in triplicates, intra- and inter-assay coefficient of variations were < 3%. The iodine laboratory was certified by the US Centers for Disease Control and Prevention EQUIP programme.

Urinary creatinine concentrations were measured on a Cobas 8000 system (Roche, Rotkreuz, Switzerland). The equipment was calibrated according to the manufacturer's instructions and external standards were included.

Calculations

Urinary iodine excretion was expressed as UIC (µg/l) in spot urine samples and as estimated 24-h iodine excretion (µg iodine/day). This was calculated as µg iodine/l urine divided by creatinine in the urine sample, multiplied with expected 24-h creatinine excretion. Values from German children using gender and height as reference values were used as expected 24-h creatinine excretion for each individual participant [10].

Statistics

Data were analysed using SPSS statistics version 22. Iodine excretion data were not normally distributed. Results were expressed as medians with interquartile range. The Mann-Whitney U test was used to compare median urinary measurements in various groups. The chi-squared test was used to compare use of dietary supplements in children with Danish ethnicity and chil-

TABLE 1

Characteristics of the children.

	1st grade students (N = 123)		5th grade students (N = 121)	
	boys	**girls**	**boys**	**girls**
n (%)	72 (58.5)	51 (41.5)	58 (47.9)	63 (52.1)
Age, mean ± SD, yrs	7.4 ± 0.5	7.3 ± 0.5	11.5 ± 0.6	11.3 ± 0.3
Weight, mean ± SD, kg	29.4 ± 5.7	25.9 ± 3.7	42.6 ± 8.8	44.1 ± 10.7
Height, mean ± SD, cm	131.3 ± 6.0	128.5 ± 5.8	152.9 ± 8.4	152.7 ± 7.4
Dietary supplement with iodine, n (%)				
Yes	29 (40.3)	17 (33.3)	12 (20.7)	18 (28.6)
No	34 (47.2)	33 (54.7)	42 (72.4)	39 (61.9)
No information	9 (12.5)	1 (2.0)	4 (6.9)	6 (9.5)
Dietary iodine supplement, %				
0 µg/day	54	66	77.8	68.4
< 70 µg/day	8	10	3.8	7.1
70 µg/day	36.5	24	7.4	7.0
> 70 µg/day	1.5	0	11.2	17.6
Dietary supplement with iodine, ethnicity, n (%)				
Danish	40 (55.6)	37 (72.5)	42 (72.4)	33 (52.4)
Other	23 (31.9)	13 (25.5)	12 (20.7)	25 (39.7)
No information	9 (12.5)	1 (2.0)	4 (6.9)	5 (7.9)

SD = standard deviation.

dren with non-Danish ethnicity. The Kruskal-Wallis H test was used to compare iodine excretion according to time of sampling. To explore which variables were associated with iodine excretion, generalised linear models were used that had log transformed iodine excretion as the dependent variable; and age group, gender, iodine supplement, ethnicity, height and body weight served as independent variables. The stepwise backwards elimination method was used.

Trial registration: not relevant.

RESULTS

Characteristics of the study participants are shown in **Table 1**. There was no significant difference between ethnicity and use of dietary supplements with iodine (p = 0.10).

Iodine excretion was lower in fifth grade students than in first grade students when expressed as a concentration, but not when expressed as estimated 24-h iodine excretion (**Table 2**). Girls had a lower iodine excretion than boys (Table 2).

Iodine excretion was significantly higher in iodine supplement users than in non-users, but iodine deficiency was not different in students with Danish ethnicity compared with students with other ethnicities (**Table 3**).

Iodine excretion did not differ according to sample time of the day. Iodine supplement (p = 0.002), age group (p = 0.02) and body weight (p = 0.04) were positively associated with the log-transformed UIC. Likewise, use of iodine supplement (p = 0.009), age group (p = 0.005) and height (p < 0.001) were positively associated with estimated 24-h iodine excretion.

UIC was significantly higher in children than in adults and in pregnant women from the same geographical area, but iodine excretion expressed as estimated 24-h iodine excretion was significantly lower in children than in adults (**Table 4**).

DISCUSSION

The median UIC was 145 (116-201) µg/l for boys and 128 (87-184) µg/l for girls, which is within the optimal range 100-199 µg/l [1]. The median UIC in schoolchildren is the recommended method for assessing the iodine status in a population [1]. However, hydration status can confound the assessment of the UIC. The estimated 24-h iodine excretion was 93 (64-127) µg/l and 77 (60-100) µg/l for boys and girls, respectively. This can be compared with the recommended intake of 120 µg/day for children aged 6-9 years and 150 µg/day for children more than nine years of age [5]. Thus, when using this comparison, the iodine excretion is low, also when taking into account that approximately 10% of the iodine in-

take is not excreted in the urine. However, the estimation of creatinine excretion is an uncertainty and use of estimated 24-h iodine excretion to express iodine intake in children has to be investigated further.

In a German study, the UIC in boys was 121 µg/l and the measured 24-h iodine excretion in the same boys

TABLE 2

Iodine excretion in first and fifth grade students, and in boys and girls, respectively. The values are median (interquartile range).

	1st grade students (n = 123)	5th grade students (n = 121)	Boys (n = 130)	Girls (n = 114)
Excretion, µg/l	145 (115-204)	132 (100-188)[a]	145 (116-201)	129 (95-189)[b]
Estimated 24-h excretion, µg/day	88 (61-114)	87 (63-117)	93 (64-127)	77 (60-100)[c]

a) p = 0.04 for difference between 1st and 5th grade students.
b) p = 0.012.
c) p = 0.03 for difference between boys and girls.

TABLE 3

Iodine excretion according to iodine supplement use and to ethnicity. The values are median (interquartile range).

	Iodine supplement		Ethnicity	
	yes (n = 76)	no (n = 148)	Danish (n = 152)[b]	other (n = 73)
Excretion, µg/l	179 (117-287)	129 (102-174)[a]	131 (102-192)	152 (113-198)
Estimated 24-h excretion, µg/day	97 (69-141)	83 (61-109)[a]	84 (62-118)	89 (62-110)

a) p < 0.01 for difference between users and non-users of dietary iodine supplements.
b) Includes mixed ethnicity if 50% Danish.

TABLE 4

Comparison of iodine excretion in children with iodine excretion in adults from the same area. The values are median (interquartile range).

	Girls/women		Boys/men	
	excretion, µg/l	estimated 24-h excretion, µg/day	excretion, µg/l	estimated 24-h excretion, µg/day
Children[a]	129 (95-189)	77 (60-100)	145 (116-201)	93 (64-127)
Adults				
18-22 yrs[b]	72 (41-134)[g]	132 (86-202)[g]	–	–
25-30 yrs[c]	75 (44-122)[g]	133 (93-203)[g]	–	–
40-45 yrs[d]	79 (44-129)[g]	143 (103-213)[g]	–	–
60-65 yrs[e]	91 (58-147)[g]	149 (107-234)[g]	108 (68-163)[g]	154 (111-219)[g]
Pregnant[f]	113 (67-175)[h]	172 (119-301)[g]	–	–

a) n =114 and 130 for girls and boys, respectively.
b) n = 251.
c) n = 262.
d) n = 344.
e) n = 177 and 195 for women and men, respectively.
f) n = 238.
g) p < 0.001.
h) p = 0.03 compared with girls/boys.

Schoolchildren in Copenhagen.

was 86 µg/day [11]. The same variables in girls were 98 µg/l and 74 µg/day, respectively. We found the same trend although we did not measure 24-h iodine excretion in the present study, but estimated it by using measured creatinine excretion and expected 24-h creatinine excretion.

We did not identify any specific groups with a low iodine excretion; iodine excretion in children with another ethnical origin than Danish was not significantly different from that of children of Danish ancestry. In line with our results, a study from Belgium found no difference in UIC between adult subjects of different ethnic origins [12]. Furthermore, children not taking iodine supplements still had an UIC above 100 µg/l. However, we cannot exclude that there are subgroups of children with a low iodine excretion, but this study is too small to identify such groups. Likewise, we identified no groups with a risk of too high iodine excretion, above 300 µg/l [1].

It is being discussed to introduce an increase in the fortification of salt in Denmark from 13 to 20 µg per g of table salt and bread salt. This is estimated to increase the median iodine intake in Danes aged 4-75 years by 28 µg per day. Thus, the discussed increase in fortification would not result in iodine excess in children.

We found no difference in iodine excretion according to time of collection of the urine. However, most of the urine samples were collected between 10 am and 2 pm, and very few samples were collected as morning urine or in the evening. Urinary iodine excretion seems to be lowest in morning urine and to peak 4-5 h after main meals [13, 14]. Thus, the median iodine excretion found in our study is a reliable measure for the median excretion as we have collected the urine samples at various times of the day and have very few collections at the time both when iodine excretion is expected to be lowest and highest.

We found that the UIC was significantly higher in schoolchildren than in adults from the same area, and that estimated 24-h iodine excretion was higher in adults than in children. This was expected as the UIC depends of the hydration and the urinary output is larger in adults than in children. Iodine intake, which is reflected in the estimated 24-h iodine excretion, is generally higher in adults than in children.

In agreement with the present study, the US NHANES study found a higher UIC in children aged 6-11 years than in adults of all ages [15]. Likewise, a study from Galicia, Spain, found an UIC of 103 µg/l in schoolchildren and an UIC of 74 µg/l in men and 77 µg/l in women in the same geographical area [16]. In a study carried out in Tasmania, schoolchildren had an UIC between 105 to 109 µg/l in the years 2003-2005, whereas pregnant women had an UIC of 78 to 88 µg/l the same years [17]. In line herewith, a study from Thailand found a higher UIC in children than in their pregnant mothers [18].

The difference between UIC in adults and children also stresses that the same cut-offs for iodine deficiency cannot be used in children and adults, as is being discussed [19].

The low participation rate was a limitation in the present study. The low participation rate among schools can (and least to some degree) be explained by the new school reform, which demands extra resources of the school staff and therefore some school headmasters refuse to participate. The participation rate among the schools and classes that agreed to take part was also low and varied from 7% to 39%. The participation rate seemed to depend on the school headmaster and the teachers' enthusiasm, the way they explained the project to parents and children through the school intranet, and the "strong" students willingness to participate. The participation rate also seemed to be higher among ethnic Danes than among children with other ethnicities. The schools in the area have a high concentration of students with non-Danish ethnicity.

A higher participation rate would have yielded a better validity. On the other hand, iodine intake is not associated with educational level or with health parameters such as smoking, alcohol intake and physical activity [3], and there is no reason to believe that iodine excretion will be different in non-participants than in participants.

CONCLUSIONS

The iodine excretion among schoolchildren in Copenhagen, an area with a relatively high iodine content in tap water, was within the recommended range when the UIC was used as a measure. A modest increase in the iodine fortification in Denmark will not change this.

LITERATURE

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